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Renal blood flow in high and low positions of aortal catheter in rabbits

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1 Introduction

Catheterization of the aorta via umbilical artery in neonates provides a convenient route for monitoring arterial blood pressure and for arterial measurement of blood gas tensions and chemistries. Thrombus formation is a common complication of this procedure [4]. Further, the most severe complication is thrombosis of the renal arteries [2]. Several authors have suggested that thrombus formation is more common if the tip of the catheter is above rather than below the aortal origins of the renal arteries [1]. Some reports, however, have shown that the frequency of complications is greater when the catheter is in low position [6].

To our knowledge there are no reports of renal blood flow (RBF) during aortal catheterization. **Because of the technical difficulties in the accurate measurement of RBF in neonates, we planned an experimental study in rabbits to evaluate RBF during aortal catheterization** when the tip of the catheter was both above and below the origins of the renal arteries.

2 Material and methods

Seven adult rabbits weighing 2500 to 3500 g were used for the experiment. The circumference of the aorta in these animals as measured at autopsy was about 10 mm. The rabbits were anesthetized with sodium pentobarbital, about 25 mg per kilogram intravenously. Local anesthesia (lignocaine) was added during preparation of the vessels. Both carotid and femoral arteries were cannulated. The carotid artery catheter was placed into the aortic arch, and the aortal catheter was inserted via the femoral artery (Fig. 1). In three of the measurements the femoral catheter was first above the origins of the renal arteries in the aorta and then pulled down before the second measurements of RBF. In four cases the order of measurements was reversed. All measurements were performed about one hour after catheterization. The blood pressure in the aorta was measured with a Hewlett-Packard transducer and recorded with a Hewlett-Packard multichannel recorder before and after the isotope measurement. The catheter used for the cannulation of the femoral artery was the same as the one used in neonates in our hospital (Argyl, A. Brunswick Co, St. Louis, U.S.A.).

RBF was measured by injecting a bolus of ^{133}Xe solution into the aorta via the carotid catheter. The activity used was about 180 MBq (5 mCi) in 1.5–2 ml. The volume of flushing saline was about 6 ml. The activity curves of the kidneys were then measured with a gamma camera (Radicamera II, General Electric, Denmark) and a small computer (Nova 1224, Data General Corp., U.S.A.; Nukab,

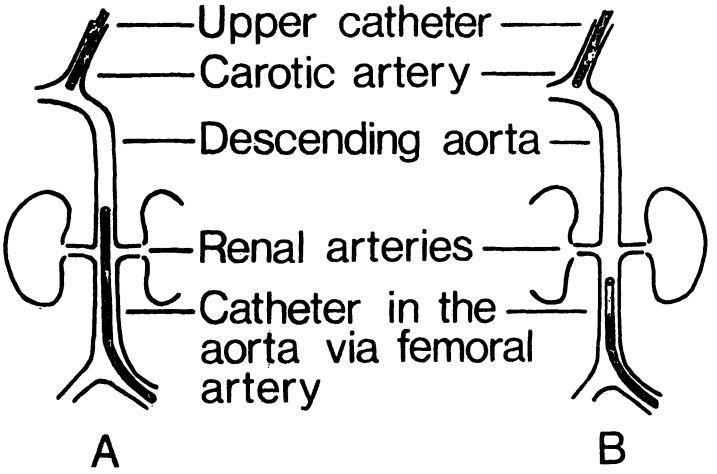

Fig. 1. The positions of the catheters in rabbits while measuring renal blood flow. The isotope bolus was injected via the carotid artery catheter. Position A: Aortal catheter above the origins of the renal arteries, and position B: The catheter below the renal arteries.

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Sweden). The measuring period after the injection was four minutes, with a time channel width two seconds. The peak count rate was 1000–2000 counts per two seconds. A two-exponential function was applied to the collected data by a iterative process. The analysed sequence of curves was 160 seconds from the top. The blood-kidney partition coefficient used was 0.8. Correction for hematocrit was unnecessary, because the perfusion values were compared in the same rabbit and in the same session.
Twenty-one measurements were done in seven rabbits. RBF could be calculated from 13 kidneys.

3 Results

The mean of the mean blood pressure values before the measurement of RBF was 112.9 mmHg (range 105–115) and after the measurement 113.4 mmHg (range 105–120). The mean value of the fast phase of RBF was 5.3 ml/g tissue/min, when the catheter was in the low position. In the high position the mean value of RBF was 5.5 ml/g tissue/min. There was no difference in the slow phase when the catheter was placed high or low, the mean of RBF being 0.16 ml/g tissue/min in both occasions (Tab. I). There were no statistically significant differences in any measurements ($p > 0.05$, paired t-test).

Tab. I. The renal blood flow in 7 rabbits during aortal catheterization with the catheter tip above and below the origins of the renal arteries.

Position of the aortal catheter	Number of kidneys	Renal blood flow (ml/g tissue/min)			
		Fast phase		Slow phase	
		Mean	SD	Mean	SD
Above the origins of renal arteries	13	5.5	1.2	0.16	0.04
Below the origins of renal arteries	13	5.3	1.2	0.16	0.04

4 Discussion

The measurement of RBF with an isotope technique is a reliable and accurate method if the isotope bolus is injected into the aorta [5]. This is also the most serious drawback of the method when considering human studies [10]. Isotope technique can be used even in measurements of blood flow of the whole organ [11]. With this method it is possible to measure intrarenal distribution of RBF [9, 12]. Our modification in following for four minutes allows measurement of only two phases, whereas ROSEN et al. [12], by following the patients during 45 minutes, could distinguish four different phases in RBF. As we did not observe any changes in our measurements it is obvious that even longer follow-up with more phases in the intrarenal distribution of RBF would not add any important information to our results. JOSE et al. [9] reported the first flow phase to be about 4.7 ml/g tissue/min in the adult dog. Our findings correspond well to these values (Tab. I).

Blood pressure is an important determinant of blood flow. The mean blood pressure in our rabbits did not change significantly when compared the values obtained before and after the measurement. Thus blood pressure caused no bias to our results. On the other hand the order of the measurements, i.e. in three rabbits first catheter in high position and in four rabbits first in low position, would decrease the effect of different variables.
The thrombosis caused by the aortal catheter appears most commonly in the aorta or in the iliac arteries [4]. Thrombosis of the renal arteries is not uncommon, either [1]. The exact mechanism of this complication is unclear. Many factors have been shown to be associated with it. Results regarding the place of the catheter are contradictory [6]. HECKER and coworkers [7] found in an experimental work in neonatal lambs that the material of the catheter used has an important value. Further, in neonates the high factor VIII activities and low concentration of antithrombin III have been suggested to be important factors, especially since at the same time the aorta is in contact with foreign material [8]. The time of catheterization seems to have little effect on the frequency of thrombus formation. GOETZMAN et al. [4] found that if there was no thrombus within 36 hours the complication did not develop later on.
In the pathogenesis of thrombus formation in renal arteries during aortic catheterization the role of renal blood flow should also be considered. The possible decrease in the blood flow caused by a relatively large catheter in the aorta added to the

above factors could be hazardous. Especially the blood flow in the small arteries supplying blood to abdominal organs may decrease. **Our findings show that a catheter placed in the aorta has no effect,** even if it is located above the origins of the renal arteries.

Although our experiments were performed in adult rabbits we believe that the results obtained are important for the situation of the newborn infant undergoing aortic catheterization. The size of the aorta which seems to be relevant for the change in blood flow, is similar in adult rabbits and newborn infants. Furthermore, the relatively low RBF, possible hypoxemia, and the higher vulnerability of newborn kidneys [3] might present additional predisposing factors for thrombus formation in the neonate. Our study suggests that RBF is not altered by a high position of aortic catheters and that, therefore, other reasons than RBF should decide on the placement of these catheters.

Summary

The effect of aortal cathetization on **renal blood flow (RBF)** was evaluated in seven rabbits weighing 2500 to 3500 g. RBF was measured 21 times from 13 kidneys during aortal catheterization with an isotope (^{133}Xe) technique. The catheter was positioned in the aorta of each rabbit both above and below the origins of the renal arteries. The results of these two measurements were compared. Two phases of RBF, a fast first phase and a slow second phase, were determined. The fast phase of RBF was 5.3 ml/g/min, when the catheter was in the low position and 5.5 ml/g/min, when it was in the high position. The results of the slow phase were identical, 0.16 ml/g/min, in both positions. No significant statistical difference could be found according to the place of the catheter (paired t-test). These results in rabbits suggest that **the aortal catheter does not cause any immediate decrease in RBF. This finding has clinical importance in aortal catheterization in neonates to obtain arterial blood samples. When considering the position of the aortal catheter in neonates factors other than RBF should be taken into account.**

Keywords: Aortal catheterization, high and low positions of catheter, neonates, renal blood flow.

Zusammenfassung

Renale Durchblutung bei hoher und tiefer Lage des Aortenkatheters in Kaninchen

In 7 Kaninchen, mit einem Gewicht zwischen 2.500 bis 3.500 g, wurde der Einfluß der Katheterlage in der Aorta auf die renale **Durchblutung (RBF)** gemessen. Mittels der Xe^{133} Isotopen-Methode wurde der RBF in 13 Nieren, 21 mal gemessen während des Katheter-vorganges. Die Katheterspitze lag in jeder Aorta einmal oberhalb und einmal unterhalb der Abzweigung der Nierenarterien. Die Ergebnisse dieser beiden Messungen wurden miteinander verglichen. Zwei RBF-Phasen, einer ersten schnellen und einer zweiten langsamen Phase, wurden bestimmt. Die schnelle Phase betrug 5,3 ml/g/min. in der tiefen Lage und 5,5 ml/g/min in der hohen Lage. In der langsamen Phase waren die Ergebnisse in beiden Positionen gleich: 0,16 ml/g/min.

Es konnte kein signifikanter Unterschied zwischen den beiden Positionen festgestellt werden (paired t-test).

Diese Resultate in Kaninchen lassen vermuten, daß ein **Aorten-Katheter keine sofortige Abnahme des RBF verursacht.** Dieses Ergebnis hat eine klinische Bedeutung bei der Nabelarterien-Katheterlage in Neugeborenen.

Bei der Lage eines Nabel-Arterien-Katheters in Neugeborenen müssen andere Überlegungen als die des RBF gemacht werden.

Schlüsselwörter: Aorta-Katheter, hohe und tiefe Katheterlage, Neugeborene, renale Blutdurchströmung.

Résumé

Mesure du flux sanguin renal en vue d'étudier l'effet d'un catheter placé en amont et en aval de l'aorte chez des lapins

L'effet de la présence d'un catheter dans l'aorte sur le flux sanguin renal (FSR) a été mesuré 21 fois dans 13 reins à l'aide de la méthode isotope Xe^{133}. Le catheter a été placé dans l'aorte de chaque lapin en amont et en aval de la bifurcation des artères renales et on a comparé les résultats de ces deux mesures. On a défini deux phases, une première rapide et une seconde plus lente. La phase rapide du FSR était de 5,3 ml/g/min quand le catheter était en position amont et de 5,5 ml/g/min quand le catheter était en position aval. Les résultats de la phase lente étaient de cative n'a été trouvée dans les deux positions du catheter. (paired t-test).

Ces résultats chez le lapin laissent penser qu'**un catheter dans l'aorte n'a pas d'influence directe sur le FSR.**

Le résultat a une importance clinique lors du placement dans l'aorte du nouveau – né d'un catheter pour des prélèvements de sang. **Quand on considère la position du catheder dans l'aorte du nouveau – né, d'autres facteurs que le FSR doivent être pris en considération.**

Mots-clés: Nouveau – nés, flux sanguin renal, catheter dans l'aorte, position amont et aval du catheter.

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